



## **Yellow Starthistle Control Methods: Biological Control**

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### **Introduction**

Classical biological control of weeds works by reuniting exotic weeds with their natural enemies. This involves searching for and identifying the natural enemies that attack the weed in its area of origin, followed by extensive testing of those natural enemies. Yellow starthistle, originated in southern Europe (France, Italy, and Greece) and Central Asia. Biocontrol agents deemed safe are imported, further tested and then released on sites here in the United States. Before a natural enemy is released in the United States, it is tested in quarantine to make sure it feeds only on the target weed species. Only those natural enemies that have a narrow range of hosts that does not include crop or native plants are introduced into California. Safety is evaluated through host specificity testing. In this process plants are exposed to the potential biological control agent and examined for feeding, eggs, larval development and adult emergence. This testing assumes that a plant's natural enemy is most likely to feed on close relatives of the target weed. Since yellow starthistle is in the same family as safflower and sunflower plants, plants in this family are frequently used as well as other closely related plants, both crop and native. Much of the initial testing occurs overseas, in the target host's area of origin in outdoor gardens or in field cages. Testing of native plants usually occurs in quarantine facilities in the United States to avoid the need to export and grow our natives in new regions where they might escape and become weeds themselves.

The advantages of biological control are that, when successful: a) It is able to keep the targeted weed population at very low levels, b) the agent feeds almost exclusively on the target weed, and c) the biological control agent can move away from the initial release sites into neighboring weed infestations and bring these under control. A disadvantage of biological control is that an intense effort over several years is required both domestically and overseas. The cost for this effort can be high, often evolving many trials and agents, but the cost-savings if control can be achieved far outweigh initial costs.

The United States Department of Agriculture has performed most of the foreign exploration and quarantine screening of yellow starthistle natural enemies. Much of the testing takes place at the Agricultural Research Service (ARS) Laboratory in Albany California. The California Department of Food and Agriculture has arranged for release of approved biocontrol agents into field sites in California, and, in cooperation with the United States Department of Agriculture-ARS, monitored their establishment and initiated studies on the impacts of each natural enemy species released. A total of five insects have been approved for release against yellow starthistle in the United States (Table 1). One species of fly was inadvertently released. All attack the flower heads and impact the plant by reducing seed production.

The California Department of Food and Agriculture's Biological Control Program has been involved in an extensive statewide distribution effort through the County Agricultural Commissioner Offices for 3 of the 5 species approved for release: *Bangasternus orientalis*, *Urophora sirunaseva*, and *Eustenopus villosus*. The California Department of Food and Agriculture puts on workshops to train county biologists and

provide them with at least 200-300 specimens of a natural enemy species which they can use to start nursery colonies in their counties. From these field nurseries, the county biologists can harvest and distribute natural enemies to private and public landowners. Individual landowners can contact their county Agricultural Commissioners Office and request yellow starthistle natural enemies. There is no charge for these insects and they are limited only by their availability, at specific times in the year.

**Table 1.**

**Natural enemies introduced into California for control of yellow starthistle (*Centaurea solstitialis*).**

Scientific Name	Common Name	Generations/ Year	Present Status
<i>Bangasternus orientalis</i>	Bud weevil	1	Widespread; common
<i>Urophora sirunaseva</i>	Gall fly	2	Widespread; common
<i>Eustenopus villosus</i>	Hairy weevil	1	Widespread; locally abundant
<i>Larinus curtus</i>	Flower weevil	1	Limited distribution
<i>Chaetorellia australis</i>	Peacock fly	2	Limited distribution
<i>Chaetorellia succinea</i>	False Peacock fly	2	Widespread; abundant



**Biocontrol Agents Approved For Release**

**The bud weevil, *Bangasternus orientalis*** is a medium sized weevil, 4.5 - 6.0 mm in length (about the size of a grain of barley) and oblong in shape. It is dark brown to black with a reddish tinge. This insect has one generation per year. Adult weevils emerge from their overwintering sites in May and are active on yellow starthistle plants from May through early July. The eggs are deposited on the leaves or stems below the young unopened buds. The eggs are covered with a black tar-like secretion from the female, which glues the egg to the leaf and prevents desiccation. Upon hatching, the larva burrows into the leaf, and up to the developing bud. It feeds on the developing seeds and disk tissue. When its growth is complete, the fat larva (now approximately 6mm long) stops feeding, forms a pupal chamber within the flower head, and pupates. Adults exit the heads in August and overwinter in protected areas such as in debris at the base of trees and along fencerows. *Bangasternus orientalis* has experienced higher than expected larval mortality in California, which appears to prevent this natural enemy from building up to high population densities. Usually 40-60% of the seeds in a head are consumed, however seed destruction can range from 30 to 100%, depending on the size of the flowerhead. The bud weevil was first released in 1985. Field collections of adults from the initial release sites have resulted in releases at over 400 sites in 49 counties throughout California. It is now widespread in the state and in Alameda and Contra Costa Counties and usually can be found wherever yellow starthistle is growing.

**The gall fly, *Urophora sirunaseva***, is a small fly approximately 3-4 mm long. Its body color is dark, usually black, and its legs are pale yellow. The wings are clear with three black crossbands and a black band along the wingtip. Males are noticeably smaller than the females. Eggs are deposited in intermediate-aged closed buds when the spines point straight up. After hatching, the larva moves to the base of the flower head and forms a woody gall, which displaces any seeds that would have formed there. Usually 1-3 galls can be found in a single flower head. This insect has two generations per year. The overwintering generation becomes active in the spring, usually April and May; the second generation is active from mid June through July. *U. sirunaseva* overwinters as a mature larva in the seed head. In the winter, yellow starthistle seed heads lose their bracts and the white cottony knap is exposed. The overwintering gall fly is located in amongst the white knap. In the spring, the larva pupates, then emerges to begin the cycle again. The impact of *U. sirunaseva* on yellow starthistle is currently under evaluation.

The formation of the gall may physically prevent seeds from being formed where the gall is located. However, the individual galls are small relative to the size of the seed head, so few seeds are displaced by a single gall. The presence of the galls may also be a drain on the overall plant resources, ultimately reducing the total number of seeds produced by the other uninfested seed heads of a plant. The presence of *U. sirunaseva* in a seed head can be checked by squeezing the head with your fingers (carefully avoiding the spines) and feeling for the hard nutlike gall among the softer parts of the head. The gall fly was first introduced in 1984. Distribution efforts by CDFA have resulted in releases at over 180 sites in 38 counties including a dozen or so from 1993-96 in Alameda and Contra Costa counties. This insect is a good flyer and has moved many miles from release sites. It is now widespread in Alameda and Contra Costa Counties and usually can be found wherever yellow starthistle grows.



**The hairy weevil, *Eustenopus villosus*** is a brown weevil slightly larger than *B. orientalis*. It is 6-8 mm long and has a long snout approximately 2-3 mm in length. Its body is covered with a mixture of long and short hairs, the long hair giving it a fuzzy or hairy appearance. The short hairs are either white or brown and create wide white lines down the back and along the sides of the adult. This insect has one generation per year. The overwintering adults emerge in May and can be active through August. Unlike the previous two natural enemies, both the adult weevil and larva feed on yellow starthistle flower heads. When the adults first become active, they feed on the young closed flower buds by chewing into the base of the bud with their long snout. This feeding kills the developing bud and, in populations with high densities of this weevil, most of the early season flowers are killed. This will cause yellow starthistle flowering to be delayed by several weeks. The plant, however, responds to this damage by producing mid to late season flowers on its lateral stems, which gives it a stunted look. Young flower buds that are not killed by adult feeding are later used by female weevils to deposit their eggs. *E. villosus* deposits its eggs in the large swollen flower buds shortly before the flowers open. The adult female chews a hole in the side of the bud, deposits the egg, then covers the hole with a mucus plug which eventually hardens. The larva hatches, burrows deeper into the head and feeds on the developing seeds. Larval feeding in a flower head causes a "wound" response by yellow starthistle. A dark hard callus tissue may be formed inside the head and plant sap may leak out over the entire flower head. In some populations, this sticky sap encourages the growth of sooty mold and gives the plants a black or dirty appearance. When ready, the larva stops feeding, forms a pupal chamber and pupates. The adults emerge in August through September and overwinter in protected areas such as the debris at the base of trees and along fencerows. The hairy weevil appears to have the greatest impact on yellow starthistle among all of the bioagents released in California to date. Unpublished field studies suggest that 50% of the flower buds may be killed by adult feeding. Of the remaining buds, 50-60% may be infested with larvae and produce few or no seeds. *E. villosus* was first introduced in 1990 with the first releases in Alameda and Contra Costa Counties in 1992. Unlike the previous two bioagents, however, this insect does not disperse well on its own, moving less than one mile in five years. It has, however, built up large populations at some release sites and collections from these sites have resulted in its distribution to over 400 sites in 48 counties. Almost 50 releases have been made in Alameda and Contra Costa Counties. More releases are warranted to make sure all areas in the two counties, especially the roadless areas, have been covered.

**The flower weevil, *Larinus curtus***, is a moderately sized weevil, similar to *E. villosus*. The adult is shiny black but, because it feeds in the open flowers, it is usually covered with bright yellow pollen. The flower weevil has one generation per year. Eggs are laid among the open flowers and the larvae feed on the developing seeds. Adult weevils emerge from the seed heads and overwinter away from their host plant. *L. curtus* was first introduced into California in 1992. It has been released at five sites in five counties but establishment has been confirmed at only three sites: one in Sutter County, another in Amador County,

and the other in Sonoma County. Follow-up surveys at the Sutter County site have revealed that some weevils are infested with the protozoan, *Nosema* sp., a parasite located in its digestive system. Studies are underway to determine the impact of this parasite on the growth and reproduction of this weevil. The Amador County site has produced an abundance of apparently parasite free weevils. In 2000 *L. curtus* was gathered from this site by county biologists from many counties including Contra Costa. A total of five releases were made in Contra Costa County in east, west and central areas. These sites will be monitored to see if the weevils will prosper and spread into adjacent areas.



**The peacock fly, *Chaetorellia australis***, is a moderate sized fly, approximately 4.5 mm long, making it slightly larger than the gall fly. The body of the peacock fly is pale orange-yellow. The wings are clear with a brown strip along the leading edge and three brown crossbands. Eggs are deposited by inserting them between the bracts of the intermediate-aged closed buds. This fly apparently requires Cornflower or Bachelor Button, *Centaurea cyanus*, to complete its life cycle. The peacock fly emerges very early in the spring, before any yellow starthistle has started to bolt. As a result, the first generation occurs on bachelor button and the second generation occurs on yellow starthistle. It has been released at 27 sites in 21 counties since 1989 but has been recovered only from Mariposa, Napa, Shasta, and Siskiyou Counties where naturalized populations of bachelor button coexist with yellow starthistle. The impact of this bioagent on yellow starthistle is yet to be determined. It is unlikely that this natural enemy will play a significant role in controlling yellow starthistle in California, as its distribution will be limited by the lack of bachelor button throughout the state. It may, however, have some impact on yellow starthistle in Oregon and Washington.

**The False Peacock Fly, *Chaetorellia succinea***, was inadvertently introduced along with *C. australis*. This species was thought to be a potential problem for the safflower crop but studies have shown a negligible effect on safflower. Less than 10 larvae were found in thousands of safflower seed heads examined for the express purpose of determining *C. succinea*'s potential for harming safflower. The fly is now widespread in California including Alameda and Contra Costa Counties and can be found nearly anywhere yellow starthistle is found. The potential of this fly is promising. Its biology is similar to *C. australis* except that it emerges a little bit later and is not dependent on a second host, completing both generations on yellow starthistle.

**It is important to know that these bioagents have yet to cause a detectable decline in yellow starthistle abundance. The biological control effort against yellow starthistle is still in its early stages. To achieve control of this weed, it will likely be necessary to introduce natural enemies that attack all parts of the plant: the root, rosette, stems, and flower heads.**

While all of the current insects attack only the flower heads, their release is the beginning of a larger, long-term effort. Several new natural enemies of yellow starthistle are currently undergoing host specificity testing by the United States Department of Agriculture, Agricultural Research Service: *Ceratopion basicorne*, a weevil that feeds on the root and stem; *Terellia uncinata*, another seed head fly; and *Puccinia jaceae*, a rust fungus that attacks the stem and leaves. Also, scientists at the California Department of Food and Agriculture are examining a new species of *Aschocyta*, which is a naturally occurring soil-borne fungus that attacks the roots of yellow starthistle seedlings.

**For further information contact your local Agricultural Commissioner**

**Alameda County 510-670-5232**

**Contra Costa County 925-646-5250**